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Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

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Advisory Action Before the Filing of an Appeal Brief	Application No.	Applicant(s)
	09/945,295	PETTITT, GREGORY S.
	Examiner	Art Unit
	Yubin Hung	2624

--The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

THE REPLY FILED 23 January 2008 FAILS TO PLACE THIS APPLICATION IN CONDITION FOR ALLOWANCE.

1. ☒ The reply was filed after a final rejection, but prior to or on the same day as filing a Notice of Appeal. To avoid abandonment of this application, applicant must timely file one of the following replies: (1) an amendment, affidavit, or other evidence, which places the application in condition for allowance; (2) a Notice of Appeal (with appeal fee) in compliance with 37 CFR 41.31; or (3) a Request for Continued Examination (RCE) in compliance with 37 CFR 1.114. The reply must be filed within one of the following time periods:
   - a) ☒ The period for reply expires 3 months from the mailing date of the final rejection.
   - b) ☐ The period for reply expires on: (1) the mailing date of this Advisory Action, or (2) the date set forth in the final rejection, whichever is later. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of the final rejection.

   Examiner Note: If box 1 is checked, check either box (a) or (b). ONLY CHECK BOX (b) WHEN THE FIRST REPLY WAS FILED WITHIN TWO MONTHS OF THE FINAL REJECTION. See MPEP 706.07(f).

Extensions of time may be obtained under 37 CFR 1.136(a). The date on which the petition under 37 CFR 1.136(a) and the appropriate extension fee have been filed is the date for purposes of determining the period of extension and the corresponding amount of the fee. The appropriate extension fee under 37 CFR 1.17(a) is calculated from: (1) the expiration date of the shortened statutory period for reply originally set in the final Office action; or (2) as set forth in (b) above, if checked. Any reply received by the Office later than three months after the mailing date of the final rejection, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

NOTICE OF APPEAL

2. ☒ The Notice of Appeal was filed on *01/23/08*. A brief in compliance with 37 CFR 41.37 must be filed within two months of the date of filing the Notice of Appeal (37 CFR 41.37(a)), or any extension thereof (37 CFR 41.37(e)), to avoid dismissal of the appeal. Since a Notice of Appeal has been filed, any reply must be filed within the time period set forth in 37 CFR 41.37(a).

AMENDMENTS

3. ☐ The proposed amendment(s) filed after a final rejection, but prior to the date of filing a brief, will not be entered because
   - (a) ☐ They raise new issues that would require further consideration and/or search (see NOTE below);
   - (b) ☐ They raise the issue of new matter (see NOTE below);
   - (c) ☐ They are not deemed to place the application in better form for appeal by materially reducing or simplifying the issues for appeal; and/or
   - (d) ☐ They present additional claims without canceling a corresponding number of finally rejected claims.

   NOTE: _____. (See 37 CFR 1.116 and 41.33(a)).
4. ☐ The amendments are not in compliance with 37 CFR 1.121. See attached Notice of Non-Compliant Amendment (PTOL-324).
5. ☐ Applicant's reply has overcome the following rejection(s): _____.
6. ☐ Newly proposed or amended claim(s) _____ would be allowable if submitted in a separate, timely filed amendment canceling the non-allowable claim(s).
7. ☐ For purposes of appeal, the proposed amendment(s): a) ☐ will not be entered, or b) ☐ will be entered and an explanation of how the new or amended claims would be rejected is provided below or appended.

   The status of the claim(s) is (or will be) as follows:

   Claim(s) allowed: _____.

   Claim(s) objected to: _____.

   Claim(s) rejected: _____.

   Claim(s) withdrawn from consideration: _____.

AFFIDAVIT OR OTHER EVIDENCE

8. ☐ The affidavit or other evidence filed after a final action, but before or on the date of filing a Notice of Appeal will not be entered because applicant failed to provide a showing of good and sufficient reasons why the affidavit or other evidence is necessary and was not earlier presented. See 37 CFR 1.116(e).
9. ☐ The affidavit or other evidence filed after the date of filing a Notice of Appeal, but prior to the date of filing a brief, will not be entered because the affidavit or other evidence failed to overcome all rejections under appeal and/or appellant fails to provide a showing a good and sufficient reasons why it is necessary and was not earlier presented. See 37 CFR 41.33(d)(1).
10. ☐ The affidavit or other evidence is entered. An explanation of the status of the claims after entry is below or attached.

REQUEST FOR RECONSIDERATION/OTHER

11. ☒ The request for reconsideration has been considered but does NOT place the application in condition for allowance because: See Appendix A.
12. ☐ Note the attached Information Disclosure Statement(s). (PTO/SB/08) Paper No(s). _____
13. ☐ Other: _____.

02/15/08

APPENDIX A

1. Applicant argues that "for a patent to be entitled to the priority of a previously-filed application, the invention of that patent must be in the previously-filed application. In other words, at least one claim of that patent must be fully supported by the previously-filed application, in order for the patent to be afforded the priority of the previously-filed application." (P. 4, paragraphs 2-4 of the request.)

2. However, regardless whether at least one claim of "that patent" (the Mendelson patent U.S. 6,559,826 at issue) is fully supported by the previously-filed application (the '826 patent's parent application S/N 09/187,161), Applicant is directed to MPEP 2136.03(IV), which states

> For prior art purposes, a U.S. patent or patent application publication that claims the benefit of an earlier filing date under 35 U.S.C. 120 of a prior nonprovisional application would be accorded the earlier filing date as its prior art date under 35 U.S.C. 102 (e), provided the earlier-filed application properly supports the subject matter relied upon in any rejection in compliance with 35 U.S.C. 112, first paragraph. In other words, the subject matter used in the rejection must be disclosed in the earlier-filed application in compliance with 35 U.S.C. 112, first paragraph, in order for that subject matter to be entitled to the earlier filing date under 35 U.S.C. 102(e).

3. The subject mater in the '826 patent relied upon for the rejection of claim 1 (see the 35 U.S.C. 103 rejections in the Office action mailed 05/10/07) includes: Fig. 6, ref. 595; Fig. 7, ref. 595b; Col. 10, lines 5-13 and 35-66; and Col. 3, lines 15-19 (providing motivation). (Figs. 9 & 11 were also included to provide additional information, but are not required for the rejection.) They are fully supported in the parent application S/N 09/187,161 at least in Figs. 6, 7 and pages 6 and 21-23.

4. Therefore, the Mendelson reference (US 6,559,826) is accorded the earlier filing date (11/06/98) of its parent application 09/187,161 and as a result the declaration filed on 09/10/07 under 37 CFR 1.131 is ineffective to overcome the Mendelson reference.

5. Accordingly, the 35 U.S.C. §103 rejections of the office action mailed 05/10/07 are maintained.

6. A copy of the patent application S/N 09/187,161 filed on 11/06/98 is attached.

UNITED STATES PATENT APPLICATION FOR

METHOD AND SYSTEM FOR PROVIDING A COLORIMETRIC REFERENCE PROFILE FOR A FLAT PANEL MONITOR

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METHOD AND SYSTEM FOR PROVIDING A COLORIMETRIC REFERENCE PROFILE FOR A FLAT PANEL MONITOR

RELATED U.S. APPLICATION

The instant application is a continuation-in-part of United States Patent Application Serial Number 09/120,960, filed July 22, 1998, entitled "System and Method for Providing a Wide Aspect Ratio Flat Panel Display Monitor Independent White-Balance Adjustment and Gamma Correction Capabilities," by Evanicky et al., and assigned to the assignee of the present invention.

FIELD OF THE INVENTION

The present invention relates to the field of display devices. More specifically, the present invention relates to the field of flat panel display devices utilizing liquid crystal display (LCD) technology.

BACKGROUND OF THE INVENTION

Flat panel liquid crystal displays (LCDs) are popular display devices for conveying information generated by a computer system. The decreased weight and size of a flat panel display greatly increases its versatility over a cathode ray tube (CRT) display. Flat panel LCD monitors are used today in many applications including the computer component and computer periphery industries where flat panel LCD monitors are an excellent display choice for lap-top computers and other portable electronic devices. Because flat panel

LCD technology is improving, more and more flat panel LCD monitors are rapidly replacing CRT displays in other mainstream applications, such as desktop computers, high-end graphics computers, and as televisions and other multi-media monitors.

In flat panel LCD monitors, much like conventional CRT displays, a white pixel is composed of a red, a green and a blue color point or "spot." When each color point of the pixel is excited simultaneously and with the appropriate energy, white can be perceived by the viewer at the pixel screen position. To produce different colors at the pixel, the intensity to which the red, green and blue points are driven is altered in well known fashions. The separate red, green and blue data that corresponds to the color intensities of a particular pixel is called the pixel's color data. Color data is often called gray scale data. The degree to which different colors can be achieved within a pixel is referred to as gray scale resolution. Gray scale resolution is directly related to the amount of different intensities, or shades, to which each red, green and blue point can be driven.

The method of altering the relative color intensities of the color points across a display screen is called white balance adjustment (also referred to as color balance adjustment, color temperature adjustment, white adjustment, or color balancing). In a display, the "color temperature" of white correlates to the relative percentage contributions of its red, green and blue intensity

components. In addition, the "color temperature" of white correlates to the luminous energy given off by an ideal black body radiating sphere at a particular temperature expressed in degree Kelvin (K). Relatively high degree K color temperatures represent "white" having a larger blue contribution (e.g., a "cooler" look). Relatively small degrees K color temperatures represent "white" having a larger red contribution (e.g., a "warmer" look). Generally, the color temperature of a display screen is adjusted from blue to red while avoiding any yellow-ish or green-ish variations within the CIE chromaticity diagram.

One disadvantage of conventional flat panel LCD screen is that its white balance cannot be dynamically adjusted. Within those conventional flat panel LCD screens, white balance can only be adjusted by altering the physical color filters used to generate the red, green and blue color points. For instance, in order to calibrate a flat panel LCD screen, an image of known chromaticity such as a white screen is displayed on the screen. Then, an expensive spectroradiometer is used to measure the tri-stimulus values of this image. If the measured values do not match the desired values, the color filters need to be physically (e.g., manually) replaced. The process is then repeated until the desired color temperature is achieved. This conventional method is costly and error-prone.

Another process of altering the white balance of a conventional flat panel LCD screen is to change to gamma of the LCD screen by altering the color look-

up tables (LUTs) of the display controller. This method, however, is undesirable because the gray-scale dynamic range of the primary colors is severely decreased, causing the display of less stable and less accurate colors.

Accordingly, it would be advantageous to provide a color balancing mechanism for a flat panel LCD screen that can respond, dynamically, to required changes in the color temperature of the display. It would also be advantageous to provide a cost-efficient mechanism and method for accurately and precisely calibrating the flat panel LCD.

SUMMARY OF THE DISCLOSURE

In accordance with the present invention, a method and system are disclosed for providing an accurate monitor-specific reference profile for a flat panel LCD monitor. In one embodiment of the present invention, the white-balance point of the flat panel LCD monitor is user adjustable. The white balance adjustment mechanisms include the provision of two pairs of light sources of differing color temperature, whose brightness can be independently varied (and distributed through a light distribution mechanism) to adjust color temperature. The flat panel LCD monitor of the present invention also provides a white-balance adjustment control input for receiving a white-balance adjustment control signal, and a control circuit responsive to the white-balance adjustment control signal for adjusting color temperature of the display by altering the brightness (intensity) of the appropriate light sources. In one embodiment of the present invention, white balance adjustment control signals are generated by the host computer.

According to one embodiment, the flat panel LCD monitor includes a memory device for storing a reference profile that is particular to that flat panel LCD monitor. In one embodiment, a colorimeter is positioned in front of the flat panel's display screen to measure its color characteristics (e.g., color temperature, tri-stimulus values, etc.) immediately after the flat panel LCD monitor is assembled at the factory. A data source (e.g., a computer system) is also coupled to the flat panel monitor's circuitry for providing video data and

control signals. Thereafter, a plurality of images of known primary colors and known relative intensities are displayed on the flat panel LCD. Chromaticity data captured by the colorimeter is then converted into data representative of the monitor's nascent chromatic characteristics. Data representative of the chromatic characteristics is then stored as part of the monitor-specific reference profile within a memory device located within the flat panel LCD monitor.

According to the present invention, the memory device can also be used to store VESA Extended Display Identification (EDID) information. Further, the monitor-specific reference profile may include firmware-specific information such as the version number of the profile. The memory device is also configured to be accessible by a host computer or a gamma sensor (e.g. luminance sensor) coupled to the flat panel LCD monitor such that the monitor-specific reference profile can be accessed during color calibration. In this way, accurate monitor calibrations can be subsequently performed with inexpensive gamma sensors in conjunction with the monitor-specific reference profile.

BRIEF DESCRIPTIONS OF THE DRAWINGS

The accompanying drawings, which are incorporated in and form a part of this specification, illustrate embodiments of the present invention and, together with the description, serve to explain the principles of the invention.

Figure 1 illustrates an exemplary computer system used as part of a computer graphics system in accordance with one embodiment of the present invention.

Figure 2 illustrates a display assembly of the present invention including wide aspect ratio display, stand and base components.

Figure 3 is a cross section through the layers of the wide aspect ratio liquid crystal display according to one embodiment of the present invention.

Figure 4 illustrates an extraction pattern disposed on the surface area of a light pipe in accordance with embodiments of the present invention that use a two light sources.

Figure 5 illustrates a cross section of the lighting configuration of the LCD panel embodiment of Figure 3 showing the orientation of the extraction patterns in accordance with the present invention.

Figure 6 a block diagram illustrating an exemplary control logic for the flat panel LCD monitor according to one embodiment of the present invention.

Figure 7 illustrates an address map of the memory device used for storing VESA EDID information and monitor-specific reference profile according to the present invention.

Figure 8 is a block diagram illustrating the system for providing a monitor-specific reference profile for a flat panel LCD monitor in accordance with the present invention.

Figure 9 is a flow diagram illustrating the steps of a process for providing a monitor-specific reference profile for a flat panel LCD monitor in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference will now be made in detail to the present embodiments of the invention, examples of which are illustrated in the accompanying drawings. While the invention will be described in conjunction with the present embodiments, it will be understood that they are not intended to limit the invention to these embodiments. On the contrary, the invention is intended to cover alternatives, modifications and equivalents, which may be included within the spirit and scope of the invention as defined by the appended claims. Furthermore, in the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be obvious, however, to one skilled in the art, upon reading this disclosure, that the present invention may be practiced without these specific details. In other instances, well-known structures and devices are not described in detail in order to avoid obscuring aspects of the present invention.

Unless specifically stated otherwise as apparent from the following discussions, it is appreciated that throughout the present invention, discussions utilizing terms such as “converting”, “determining”, “analyzing”, “storing”, or the like, refer to the actions and processes of a computer system, or similar electronic computing device. The computer system or similar electronic device manipulates and transforms data represented as physical (electronic) quantities within the computer system’s registers and memories into other data similarly

represented as physical quantities within the computer system memories into other data similarly represented as physical quantities within the computer system memories or registers or other such information storage, transmission, or display devices.

COMPUTER SYSTEM ENVIRONMENT OF THE PRESENT INVENTION

With reference to Figure 1, portions of the present invention are comprised of computer-readable and computer executable instructions which reside, for example, in computer-usable media of a computer system. Figure 1 illustrates an exemplary computer system 10 used as a part of a system for providing a monitor-specific reference profile for a flat panel monitor in accordance with one embodiment of the present invention. It is appreciated that computer system 10 of Figure 1 is exemplary only and that the present invention can operate within a number of different computer system platforms including general purpose computer systems, embedded computer systems, and stand alone computer systems specially adapted for generating and displaying graphics images. It is also appreciated that the various aspects of the present invention can be made to function if the flat panel monitor is addressed by a remote computer system, or a "server," which also interacts with other similar flat panel monitors within its network.

Computer system 10 of Figure 1 includes an address/data bus 11 for communicating information, and a central processor unit 12 coupled to bus 11

for processing information and instructions. Computer system 10 also includes data storage features such as computer-usable volatile memory 14, e.g. random access memory (RAM), coupled to bus 11 for storing information and instructions for central processor unit 12, computer-usable non-volatile memory 13, e.g. read only memory (ROM), coupled to bus 11 for storing static information and instructions for the central processor unit 12, and a data storage device 15 (e.g., a magnetic or optical disk and disk drive) coupled to bus 11 for storing information and instructions. Computer system 10 further includes a serial port 18 for coupling to peripheral devices such as a color sensing device. A graphics subsystem 19, which may include a graphics co-processor for offloading computation burden from central processor unit 12 and embedded DRAM for increased memory bandwidth, coupled to bus 11, is also included in computer system 10 of Figure 1. In one embodiment, graphics subsystem 19 is configured for coupling to a flat panel LCD monitor.

Computer system 10 of the present invention also includes an optional alphanumeric input device 16 including alphanumeric and function keys coupled to bus 11 for communicating information and command selections to central processor unit 12. Computer system 10 also optionally includes a cursor control device 17 coupled to bus 11 for communicating user input information and command selections to central processor unit 12. Optional cursor control device 17 allows the computer user to signal dynamically the two-dimensional movement of a visible symbol (cursor) on a display screen. Many

implementations of cursor control device 17 are known in the art including a trackball, mouse, touch pad, joystick, or special keys on alphanumeric input device 16 capable of signaling movement of a given direction or manner of displacement. Alternatively, it will be appreciated that a cursor can be directed and/or activated via input from alphanumeric input device 16 using special keys and key sequence commands. The present invention is also well suited to directing a cursor by other means such as, for example, voice commands. Computer system 10 may further include a communication device (e.g. a modem) for communicating with a computer network.

GENERAL DESCRIPTION OF A FLAT PANEL LCD MONITOR IN ACCORDANCE WITH THE PRESENT INVENTION

Figure 2 illustrates a monitor 216 in accordance with the present invention. The monitor 216 includes a display screen 210 for viewing high information content display. The flat panel display screen 210 ("display 210") of the present invention is digitally addressed in an (x, y) matrix of pixels over the entire area of the display. Display screen 210 includes a thin film transistor (TFT) liquid crystal display layer. The monitor 216 also includes a height adjustable stand 214 that is supported by base 212. Stand 214 (or "tower") allows both elevation and tilt adjustments. The monitor 216 of the present invention has a high resolution for the display of high information content, such as graphics images and/or textual information including alphanumeric characters.

The monitor 216, in one implementation, supports the SXGA-Wide display format. The SXGA-Wide display format has 1,600 pixels across the horizontal dimension and 1,024 pixels down the vertical dimension. The aspect ratio of the SXGA-Wide compliant implementation of the monitor of the present invention is approximately 1.6 : 1. Within the context of the present invention, an aspect ratio greater than 1.3 : 1 is considered to be a wide aspect ratio. The present embodiment having a display screen of 369.6 mm by 236.54 mm is therefore a large viewing area wide aspect ratio flat panel display unit. Because the pixel pitch (e.g., the distance between pixel centers) of the monitor 216 is 0.231 mm, it is very well suited for the display of textual information (e.g., alphanumeric characters) as well as graphic images, both being high information content. It should be noted that the present implementation is exemplary only, and that the present invention may be embodied in flat panel monitors that support other display formats.

Therefore, the monitor 216 of the present invention is well suited for desktop publishing applications, graphics design applications, digital photography and video applications, medical imaging, pre-press soft-proofing, etc. A more detailed description of the wide aspect ratio flat panel LCD monitor 216 can be found in co-pending United States patent application serial number 09/120,983, filed July 22, 1998, and entitled "A Large Area Wide Aspect Ratio

Flat Panel Monitor Having High Resolution For High Information Content Display," which is hereby incorporated by reference.

Figure 3 is a cross section of the layers of the flat panel display screen 210 in accordance with one embodiment of the present invention. The flat panel display screen 210 can be used with a fixed-in-place backlighting unit or can be used with a removable backlighting assembly. Also, although Figure 3 illustrates an edge lighting embodiment, display 210 can also be directly backlit as described further below. The layers of display screen 210 are described with respect to Figure 3 from the bottom up ending with the viewed surface 210a.

The flat panel display 210, in accordance with one embodiment of the present invention, provides white balance adjustment by independently varying the brightness of two pairs of light sources (e.g., cold cathode flourescent CCF tubes) 132 and 136 that belong to a lighting configuration 160. For a predetermined range of color temperatures, having a minimum temperature (e.g., 5,000 K) and a maximum temperature (e.g., 7,000 K), a first pair of light sources 132 are provided that have a wavelength spectrum with an overall color temperature less than the minimum temperature of the predetermined range; herein, light sources 132 with this characteristic are called the "red" light sources for convenience. Also, a second pair of light sources 136 are provided that has a wavelength spectrum with an overall color temperature that is greater than the maximum temperature of the predetermined range; herein, light

sources 136 with this characteristic are called the “blue” light sources for convenience.

Also in the lighting configuration 160 shown in Figure 3, the red light sources 132 are optically coupled to provide light to a light pipe 130. The red light sources 132 are positioned along an edge of the light pipe 130. Likewise, the blue light sources 136 are optically coupled to provide light to light pipe 130. The blue light sources 136 are also positioned along an edge of light pipe 130. In the embodiment 160 of Figure 3, the light sources 132 and 136 are long thin tubes which are positioned on opposite sides of the planar light pipe 130. The light sources 132 and 136 are positioned to be substantially parallel with each other. The power supply for each pair of light source 132 and 136 receive a separate voltage signal for independently controlling its brightness with respect to the other pair of light source. It is appreciated that the positions of the red tubes 132 and the blue tubes 136 can be switched without departing from the scope of the invention.

Other embodiments of the light configuration in accordance with the present invention, such as “L-shaped” light tubes, may be found in co-pending United States patent application serial number 09/087,745 , filed on May 29, 1998, and entitled “A Multiple Light Source Color Balancing System Within A Liquid Crystal Flat Panel Display,” and prior-noted co-pending United States patent application serial number 09/120,983, filed July 22, 1998, and entitled “A

Large Area Wide Aspect Ratio Flat Panel Monitor Having High Resolution For High Information Content Display," both of which are hereby incorporated by reference.

Within display screen 210 of Figure 3, a rear reflector layer 138 is positioned on one side of the light pipe 130. On the other side of the light pipe 130, diffuser layers 460 and 467 (mylar) are positioned next to one or more brightness enhancement layers (BEFs) 465. An air gap 455 is then disposed. Layer 460 can optionally be covered by a protective layer (not shown). Layer 460 is then followed by a back or rear polarizer layer 450 that is positioned next to the air gap 455. The display screen 210 includes the back polarizer layer 450 followed by bi-refringegent compensation film 445 which is followed by a back glass layer 440.

The back glass layer 440 of Figure 3 is followed by a selectively energized transistor layer 435 ("TFT layer") and an LCD layer 430, followed by red/green/blue color filter layers 425. The TFT layer 435 is composed of selectively addressed amorphous silicon thin film transistors (TFT) which charge up their respective capacitors. The color filter layer 425 is followed by a front glass layer 420. The front glass layer 420 is followed by another compensation film layer 415 (e.g., a birefringence compensation film layer) which is followed by a second or front polarizer layer 410. A protective coating

layer 405 is placed in front of the front polarizer layer 410 and provides a non-glare viewing surface.

The white balance or color temperature of display screen 210 is maintained and adjusted using the two pairs of independently controlled light sources 132 and 136. The white balance is adjusted by altering the brightness of the pairs of light sources 132 and 136 independently. The phosphor ratios (e.g., contribution of red, green and blue phosphors) of the two pairs of light sources 132 and 136 are selected so that the white balance can be adjusted by varying the intensities of the light sources 132 and 136. The light pipe 130 is acrylic and contains an extraction system that uniformly and independently distributes the light from each light source across the viewing area of the display, thereby providing the color-adjusted light uniformly over display 210.

Significantly, the present invention provides for a mechanism and method for adjusting its color temperature by adjusting the brightness of the two pairs of light sources 132 and 136 of lighting configuration 160. Particularly, the monitor 216 includes an white-balance adjustment control signal input configured for coupling to a digital computer system to receive a white-balance adjustment control signal, and control circuitry responsive to the white-balance adjustment control signal for controlling the brightness of the two pairs of light sources 132 and 136. In addition, in one embodiment of the present invention, the monitor 216 further comprises circuitry configured for coupling to a light-

sensing device (e.g., colorimeters, luminance sensors, etc.) that measures optical characteristics of the display screen 210.

Figure 4 illustrates a top view of an exemplary extraction pattern 144a that can be applied to the bottom of light pipe 130 within display screen 210. The extraction pattern 144a is designed to uniformly illuminate the LCD layer 430, at any brightness. Extraction dots are applied directly to the lower surface of the light pipe 130. To accomplish this uniform distribution of light, extraction dots generally decrease in size in a proportion to their distance from the middle of the light pipe 130. Extraction dots 150a are smaller since they are relatively close to the light sources 132 and 136. Extraction dots 150b are slightly larger since they are relatively farther from to the light sources 132 and 136 than dots 150a. It is appreciated that extraction pattern 144a also includes larger sized dots 150d at the corners near the light source 132 because the tube 132 is not as bright at the ends as in the middle sections of the tube. Variations in the extraction dot patterns, which may be equally applied to the present invention, may be found in United States patent 5,593,221, by Evanicky et al., which is assigned to the assignee of the present invention, and which is hereby incorporated by reference.

Figure 5 illustrates the lighting configuration 160 of light pipe and light sources (as shown for display 210 of Figure 3) taking into consideration the orientation of its light extraction pattern. Within display screen 210, extraction

pattern 144a is designed to uniformly distribute light to the LCD layer 430, as the brightness of light sources 132 and 136 varies. Light extraction pattern 144a is shown in Figure 5 in cross section as a thin line applied to the underside of light pipe 130. As shown, the dot sizes decrease within pattern 144a from the middle of the light pipe 130 towards the edges of the light pipe 130.

SYSTEM FOR AND METHOD OF PROVIDING A MONITOR-SPECIFIC REFERENCE PROFILE FOR A FLAT PANEL LCD MONITOR ACCORDING TO THE PRESENT INVENTION

Figure 6 is a block diagram illustrating control circuitry 550 of the monitor 216 of the present invention. Control circuitry 550 includes LCD display circuit 500, inverter circuit 570, and system electronics 590. As illustrated, LCD display circuit 500 receives video data from an information originating source, e.g. computer system 10, via a dual channel low voltage differential voltage signals (LVDS) bus 515, and displays an image representative of the image data by selectively energizing transistors within transistor layer 435 (Figure 3). Circuit 500 includes LCD display electronics that are well known in the art. Therefore, specific implementation details of the LCD display circuit 500 are not described herein to avoid obscuring aspects of the present invention.

With reference still to Figure 6, according to the present embodiment, inverter circuits 570 are used to control the light sources (e.g., 132 and 136, etc.) described above in the lighting configurations. The inverter circuitry 570 contains the provision for independently providing power to each light source (e.g., at an operating voltage of 745 volts with a striking voltage capability of 2,000 volts) thereby allowing independent dimming control of each light source. Each inverter circuit of 570 contains a transformer for supplying a high voltage signal to the light sources 132 and 136 and also contains a switch circuit for turning the tubes off. Light sources 132 and 136 are separately coupled to receive power from power supply lines 580a-580b. In one embodiment, the current supplied to the inverter circuitry 570 is approximately 2 amps at 12 volts.

In the present embodiment, operations of the inverter circuits 570 are controlled by system control circuitry 590 which receives control signals from computer system 10 via an inter-integrated circuit (I2C) interface. In the particular embodiment as illustrated, system control circuitry 590 further comprises an interface for coupling to a light-sensing device 610. In this way, chromaticity data may be transmitted directly from the light sensing device 610 to the flat panel LCD monitor 216. Control signals may also be transmitted from computer system 10 to the light-sensing device 610 via flat panel LCD monitor 216.

In the present embodiment, system control circuitry 590 further comprises a memory device 595 for storing a monitor-specific reference profile of the flat panel LCD monitor 216. VESA's EDID information may also coexist in the same memory device 595. VESA's EDID standard is defined by the EDID version 3 specification and uses the 1.2 data structure, and is hereby incorporated by reference. According to the present invention, the information stored within the memory device 595 is accessible by a light-sensing device (not shown) and by computer system 10. Further, the memory device 595 may be a erasable-programmable read-only-memory (EPROM), programmable read-only-memory (PROM), flash memory, or any other types of non-volatile memory devices. Details of the memory device 595 and the monitor-specific reference profile will be discussed below.

In order to provide sufficient bandwidth for rendering images on the monitor 216, in the present embodiment, a dual channel LVDS interface is used where video data is sent at the rate of two pixels for each LVDS output clock. An exemplary implementation of the present dual channel LVDS bus and an I2C interface for a flat panel LCD monitor can be found in co-pending United States patent application serial no. 09/121,276, filed July 22, 1998, entitled "Digital Interface for Digital Flat Panel Monitors", by Medina, which is hereby incorporated by reference. It should be appreciated that, although LVDS signal standard is employed in one embodiment of the present invention, other signal transmission standards can also be used by the present invention for the

display signal including emitter coupled logic (ECL) and transition minimized differential signaling (TMDS) technologies. It should be apparent to those of ordinary skill in the art that other signal transmitting standards having sufficient bandwidth and suitable for supporting an SXGA-WIDE display format may also be used.

Figure 7 illustrates an address map of the memory device 595 of Figure 6. According to the present invention, the memory device 595 may be used for storing the monitor-specific reference profile, and may be used for storing VESA's EDID information.

In the illustrated embodiment, the memory device 595 has a capacity of 256 x 8-bits (256 bytes) and is organized with an address scheme ranging from 0 to 255. It is appreciated that the size of 256 bytes is exemplary only and memory 595 can be of any size. Particularly, memory device 595 includes two memory sections: a first memory section 595a, and a second memory section 595b. In the present embodiment, the first memory section 595a is programmed to store EDID information, and the second memory section 595b is programmed to store a monitor-specific reference profile of flat panel LCD monitor 216. VESA EDID is well known in the art, and is defined by the VESA-EDID standard. It should be appreciated, however, that the address scheme illustrated in Figure 7 is exemplary only, and that the present invention may be embodied in other memory addressing schemes as well.

According to the present invention, the monitor-specific reference profile includes data representative of a collection of tri-stimulus values recorded during factory calibration of the flat panel LCD monitor. Typically, the information is programmed into the memory device 595 shortly after the monitor 216 is assembled in a factory during factory-calibration. The memory device 595 may also be programmed any time during the service life of the monitor 216 to update its reference profile. Specific details of the programming process will be described below.

Significantly, memory device 595 is accessible by a host computer (e.g. computer system 10), and by a light-sensing device 610 (e.g., a gamma sensor) that is coupled to the flat panel LCD monitor 216. The memory device 595, which stores the monitor-specific reference profile, allows users to subsequently calibrate the flat panel LCD monitor 216 to a desired color temperature and white-balance point by using an inexpensive gamma (or luminance) sensor. A method of calibrating the flat panel LCD monitor 216 using an inexpensive gamma (or luminance) sensor is described in co-pending United States patent application serial number 09/120,960, filed July 22, 1998, entitled "System and Method for Providing a Wide Aspect Ratio Flat Panel Display Monitor Independent White-Balance Adjustment and Gamma Correction Capabilities", by Evanicky et al, which is assigned to the present assignee and which is hereby incorporated by reference.

Figure 8 is a block diagram illustrating a system 800 for providing a monitor-specific reference profile for the flat panel LCD monitor 216 in accordance with the present invention. Specifically, the system 800 of the present invention includes a computer system 10, a flat panel LCD monitor 216 with display screen 210 and memory device 595, and a colorimeter 810. In one embodiment of the present invention, colorimeter 810 may be a ChromaTech IV colorimeter which is available from Sequel Imaging, Inc. of Londonderry, New Hampshire. However, it is appreciated that other colorimeters or spectroradiometers, such as Color Analyzer CA-110, manufactured by Minolta Co. of Japan, may also be used. These colorimeters are well known in the art, and, therefore, specific details of these colorimeters are not described herein to avoid obscuring aspects of the present invention.

With reference still to Figure 8, computer system 10 is coupled to flat panel LCD monitor 216 for providing video data and control signals. As discussed above, video data may be transmitted via a dual channel LVDS data bus, and control signals may be transmitted via an I2C interface running in parallel with the dual channel LVDS data bus. In one embodiment of the present invention, computer system 10 provides control signals for adjusting a white balance point of the display screen 210 by adjusting the relative intensity of the light sources 132 and 136 (Figure 3).

In operation, during factory calibration, the computer system 10 generates video data corresponding to a plurality of images of known primary colors at known relative light-source intensity levels, and transmits the video data to the flat panel LCD monitor 216 to be displayed on display screen 210. In the present embodiment, each image is displayed at four different combinations of relative light-source intensity levels. Particularly, in one embodiment, each image is displayed with the "red" and "blue" lamps set at the following relative intensity levels shown in Table 1 below:

Table 1

"Red" Lamp 132	"Blue" Lamp 136
High	High
High	Low
Low	High
Low	Low

The colorimeter 810 then measures the chromatic characteristics (e.g., tri-stimulus values Yxy) of the images as they are displayed, and stores the measured values within computer system 10. It should be appreciated that, in the present embodiment, the colorimeter 810 is controlled by computer system 10 such that capturing of the chromatic characteristics can be performed synchronously with the displaying of the images and the adjusting of the color temperature.

After the necessary chromatic measurements are recorded, they are stored as a monitor-specific reference profile within memory device 595. The

format of the monitor-specific reference profile is arbitrary. However, in the present embodiment, the reference profile needs to be stored within the available memory of the memory device 595.

Figure 9 is a flow diagram illustrating a process 900 for providing a monitor-specific reference profile for a flat panel LCD monitor in accordance with the present invention. It should be appreciated that the process 900 as illustrated in Figure 9 is preferably carried out at the factory where the flat panel LCD monitor 216 is assembled. However, process 900 may also be carried out at any later point in the monitor's service life (e.g. after new light sources are installed) in order to have its reference profile re-entered into memory 595.

As illustrated, at step 910, a flat panel LCD monitor 216 is turned on, and warmed up for several minutes. According to the present invention, the chromatic characteristics of a display screen of a flat panel LCD monitor 216 are somewhat unstable during the first few minutes of operation, and, therefore, monitor 216 is preferably warmed-up for several minutes before chromatic characteristics are measured. However, it should be noted that the chromaticity values (e.g. tri-stimulus values Yxy) change in a known and predictable manner provided that the enviromental conditions, the start conditions, and the monitor package design remain the same. Therefore, it is possible to enter known offsets into the Yxy measurements if the calibrator wishes to shorten the process to just two to five minutes.

As illustrated, at step 920, a series of images having known primary colors are displayed at known relative light-source intensity levels on the display screen 210 of the flat panel LCD monitor 216. In the present embodiment, each image is displayed with the "red" lamps 132 and "blue" lamps 136 set at the relative intensity levels as shown in Table 1 above. For example, an image with pixel values corresponding to pure white (e.g., RGB full on) is displayed at the four different relative light-source intensity levels listed above. Then, an image with pixel values corresponding to pure red (e.g., R-pixels full on, G-pixels and B-pixels full off) is displayed at those relative light-source intensity levels. The process is repeated for a collection of different color values including green and blue. A collection of other various shades of red, green, and blue may also be displayed such that the natural gamma values of the display screen 210 can be more accurately determined. It should be appreciated, however, that many other combinations of the intensity levels may also be used to achieve the goals of the present invention.

At step 930, the chromaticity values of the images actually displayed are measured by a colorimeter. The colorimeter used may be an expensive color analyzer specifically designed for measuring tri-stimulus values of LCD panels, such as Color Analyzer CA-110 of Minolta Co., and Chromatek IV from Sequel Imaging, Inc. It should be appreciated that step 920 is carried out concurrently with step 910 such the chromatic characteristics of the images may be

measured when they are displayed. According to the present invention, the chromaticity of the displayed images becomes unstable after the relative intensity levels of the light sources 132 and 136 are adjusted. Therefore, in the present embodiment, measurements are preferably taken thirty to forty seconds after an adjustment to the intensity levels is made such that transient chromatic instability of the LCD display screen can be avoided.

At step 940 of Figure 9, the measured chromatic values (e.g. tri-stimulus values Yxy) are analyzed and are converted to a monitor-specific reference profile. In the present embodiment, the monitor-specific reference profile includes data representative of the tri-stimulus values of the primary color components Red, Green, and Blue. In addition, the monitor-specific reference profile may include data representative of the luminance ramp for the display screen 210, and the digital control settings corresponding to certain color temperatures. The format in which the monitor-specific reference profile may be stored is arbitrary. For example, the monitor-specific reference profile may be stored in a manufacturer's proprietary format, or in the International Color Consortium (I.C.C.) profile format.

At step 950, firmware-specific information, such as the version number and format of the reference profile, are appended to the monitor-specific reference profile. According to the present embodiment, the firmware-specific information may be accessed by a host computer system 10 such that the host

computer system 10 may determine the reference profile's status and storage format. The firmware-specific information, in one embodiment, is primarily used for error-checking purposes.

At step 960, the monitor-specific reference profile is stored in a memory device, such as memory device 595, within flat panel LCD monitor 216. In one embodiment of the present invention, VESA EDID information and the monitor-specific reference profile are stored within the same physical memory device 595. Thus, in order to streamline the manufacturing process, VESA EDID information and the monitor-specific reference profile may be stored in the same memory device 595 during the same burn-in process. Thereafter, the process ends.

The present invention, a method of and system for providing a colorimetric reference profile for a flat panel LCD monitor has thus been disclosed. The monitor-specific reference profile provides a reference point from which future calibration calculation can be based. More significantly, the monitor-specific reference profile allows the flat panel LCD monitor to be calibrated subsequently using only an inexpensive gamma (or luminance) sensor. Additionally, this profile may be used to track the various colorimetric qualities of the monitor as its components (e.g., lamps, lightpipes, films, etc.) age over time in order to constantly color calibrate the monitor. While the present invention has been described in particular embodiments, it should be

appreciated that the present invention should not be construed as limited by such embodiments, but should be construed according to the below claims.

METHOD AND SYSTEM FOR PROVIDING A COLORIMETRIC REFERENCE PROFILE FOR A FLAT PANEL MONITOR

CLAIMS

What is claimed is:

1. A method for providing colorimetric reference profile for a flat panel liquid crystal display monitor including a first light source having a first color temperature and a second light source having a second color temperature, said method comprising the steps of:

displaying a plurality of images having known primary color components at known relative intensity levels of said light sources;

synchronous with said step of displaying, measuring actual chromaticities of said displayed images with a colorimeter;

analyzing said actual chromaticities to generate a set of chromaticity data;

converting said set of chromaticity data into a monitor-specific reference profile unique to said monitor, said monitor-specific reference profile representative of nascent characteristics of said monitor; and

storing said monitor-specific reference profile within a memory device of said monitor.

2. The method according to Claim 1 wherein said set of chromaticity data comprises tri-stimulus values for each of the primary color components, Red, Green and Blue, of said flat panel monitor and data representative of digital settings of said light sources when said tri-stimulus values are measured.

3. The method according to Claim 2 wherein said set of chromaticity data further comprises a luminance ramp of said monitor.

4. The method according to Claim 1 further comprising the step of storing VESA EDID information within said memory device.

5. The method according to Claim 4 wherein said memory device comprises a first memory section for storing said VESA EDID information and a second memory section for storing said monitor-specific reference profile.

6. The method according to Claim 1 further comprising the step of storing VESA EDID information within another memory device.

7. The method according to Claim 1 wherein said step of measuring further comprises the step of waiting for a predetermined period after each image is displayed to avoid transient chromatic instability of said monitor.

8. The method according to Claim 7 wherein said predetermined period is approximately thirty seconds.

9. A flat panel monitor comprising:

an image data input for coupling to a host computer to receive image data;

a liquid crystal display screen for displaying a representation of said image data; and

a memory device for storing a monitor-specific reference profile unique to said flat panel monitor, wherein said monitor-specific reference profile includes data representative of nascent chromatic characteristics of said flat panel monitor.

10. The flat panel monitor as recited in Claim 9 further comprising:

a first light source having a first color temperature;

a second light source having a second color temperature, said first and second light sources positioned to illuminate said liquid crystal display screen with light having a net color temperature that is dependent on an intensity of said first light source and an intensity of said second light source;

a white-balance adjustment control input for receiving a white-balance adjustment control signal from said host computer; and

a controller circuit responsive to said white-balance adjustment control signal for adjusting relative intensity levels of said light sources to alter said net color temperature of said liquid crystal display screen.

11. The flat panel monitor as recited in Claim 10 wherein said monitor-specific reference profile further comprises data representative of tri-stimulus values of each of the primary color components, Red, Green and Blue, of said flat panel monitor at predetermined relative intensity levels of said light sources.

12. The flat panel monitor as recited in Claim 9 wherein said monitor-specific reference profile further comprises data representative of a luminance ramp of said flat panel monitor.

13. The flat panel monitor as recited in Claim 9 wherein said memory device further comprises VESA EDID information of said flat panel monitor.

14. The flat panel monitor as recited in Claim 9 further comprising another memory device for storing VESA EDID information of said flat panel monitor.

15. The flat panel monitor as recited in Claim 9 wherein said memory device comprises an erasable-programmable read-only-memory (EPROM).

16. The flat panel monitor as recited in Claim 9 wherein said monitor-specific reference profile further comprises firmware-specific information for error-checking.

17. The flat panel monitor as recited in Claim 9 further comprising a gamma sensor for measuring luminance levels of said liquid crystal display screen, wherein said luminance levels are for comparing with said nascent characteristics stored in said memory device to track aging characterisitics of said liquid crystal display screen.

18. A method of calibrating a flat panel monitor having a liquid crystal display screen having independently variable light sources with different color temperatures, said method comprising the steps of:

accessing a memory device located within said flat panel monitor to retrieve a monitor-specific reference profile stored within said memory device, said monitor-specific reference profile containing data representative of nascent chromatic characteristics of said liquid crystal display screen;

displaying a plurality of images having known primary colors at known relative intensity levels of said light sources;

synchronous with said step of displaying, measuring actual luminance values of said images one image at a time with a gamma sensor; and

analyzing said actual luminance values and said nascent chromatic characteristics to determine appropriate calibration parameters for said flat panel monitor.

19. The method as recited in Claim 18 wherein said monitor-specific reference profile comprises data representative of tri-stimulus values of said flat panel monitor and data representative of relative intensity levels of said light sources when said tri-stimulus values are measured.

20. The method as recited in Claim 18 wherein said monitor-specific reference profile comprises data representative of a luminance ramp of said flat panel monitor.

21. The method as recited in Claim 18 wherein said memory device further includes VESA EDID information of said flat panel monitor.

22. The method as recited in Claim 18 wherein said monitor-specific reference profile further comprises data identifying a version number of said profile.

23. The method as recited in Claim 18 further comprising the step of comparing said actual luminance values with said nascent chromatic

characteristics of said liquid crystal display screen to track aging characteristics of said liquid crystal display screen.

24. A flat panel monitor comprising:

(a) an image data input for receiving image data from a host computer;

(b) a liquid crystal display screen for displaying said image data, said liquid crystal display screen comprising:

(i) a first light source of a first color temperature;

(ii) a second light source of a second color temperature different from said first color temperature, said first and second light sources positioned to illuminate said liquid crystal display screen with light having a net color temperature that is dependent on an intensity of said first light source and an intensity of said second light source wherein said first and said second light sources alter said net color temperature of said light, within a predetermined color temperature range, by controlling said intensity of said first light source and said intensity of said second light source;

(c) a white-balance adjustment control input for receiving a white-balance adjustment control signal from said host computer, said white-balance adjustment control signal for adjusting said intensity of said first

light source and said intensity of said second light source to adjust said net color temperature of said liquid crystal display screen; and

(d) a memory device accessible by said host computer for storing a monitor-specific reference profile of said flat panel monitor, said monitor-specific reference profile including data representative of nascent chromatic characteristics of said flat panel monitor.

25. A system for providing colorimetric reference profile for a flat panel monitor including a first light source having a first color temperature and a second light source having a second color temperature, said system comprising:

a host computer coupled to said flat panel monitor for providing image data representative of a plurality of images of known primary color components at known relative intensity levels of said light sources;

a colorimeter for generating a set of chromaticity data representative of actual chromaticities of said images and for transmitting said set of chromaticity data to said host computer, said host computer for converting said set of chromaticity data into a monitor-specific reference profile representative of nascent characteristics of said monitor; and

a memory device within said monitor coupled to said host computer for receiving said monitor-specific reference profile and for storing said monitor-specific reference profile.

26. The system as recited in Claim 25 wherein said flat panel monitor further comprises:

a liquid crystal display screen and wherein said first and second light sources are positioned to illuminate said liquid crystal display screen with light having a net color temperature that is dependent on an intensity of said first light source and an intensity of said second light source;

a white-balance adjustment control input for receiving a white-balance adjustment control signal from said host computer; and

a controller circuit responsive to said white-balance adjustment control signal for adjusting relative intensity levels of said light sources to alter said net color temperature of said liquid crystal display screen.

27. The system as recited in Claim 25 wherein said monitor-specific reference profile further comprises data representative of tri-stimulus values of each of the primary color components, Red, Green and Blue, of said flat panel monitor at predetermined relative intensity levels of said light sources.

28. The system as recited in Claim 25 wherein said monitor-specific reference profile further comprises data representative of a luminance ramp of said flat panel monitor.

METHOD AND SYSTEM FOR PROVIDING A COLORIMETRIC REFERENCE PROFILE FOR A FLAT PANEL MONITOR

ABSTRACT OF THE DISCLOSURE

A system and method for providing colorimetric reference profile for a flat panel liquid crystal display monitor. In one embodiment of the present invention, the white-balance point of the flat panel LCD monitor is user adjustable. The white balance adjustment mechanisms may include the provision of two or more pairs of light sources of differing color temperatures, whose brightness can be independently varied (and distributed through a light distribution mechanism) to adjust the overall color temperature. The flat panel monitor also includes a memory device for storing a monitor-specific reference profile containing data representative of nascent chromatic characteristics of the monitor which are determined when the flat panel monitor is newly manufactured. In one embodiment, the reference profile includes nascent tristimulus values corresponding to various color and data representative of a luminance ramp of the monitor. The monitor-specific reference profile can be stored together with VESA EDID information within an EPROM that is programmed at the factory where the monitor is assembled.

10

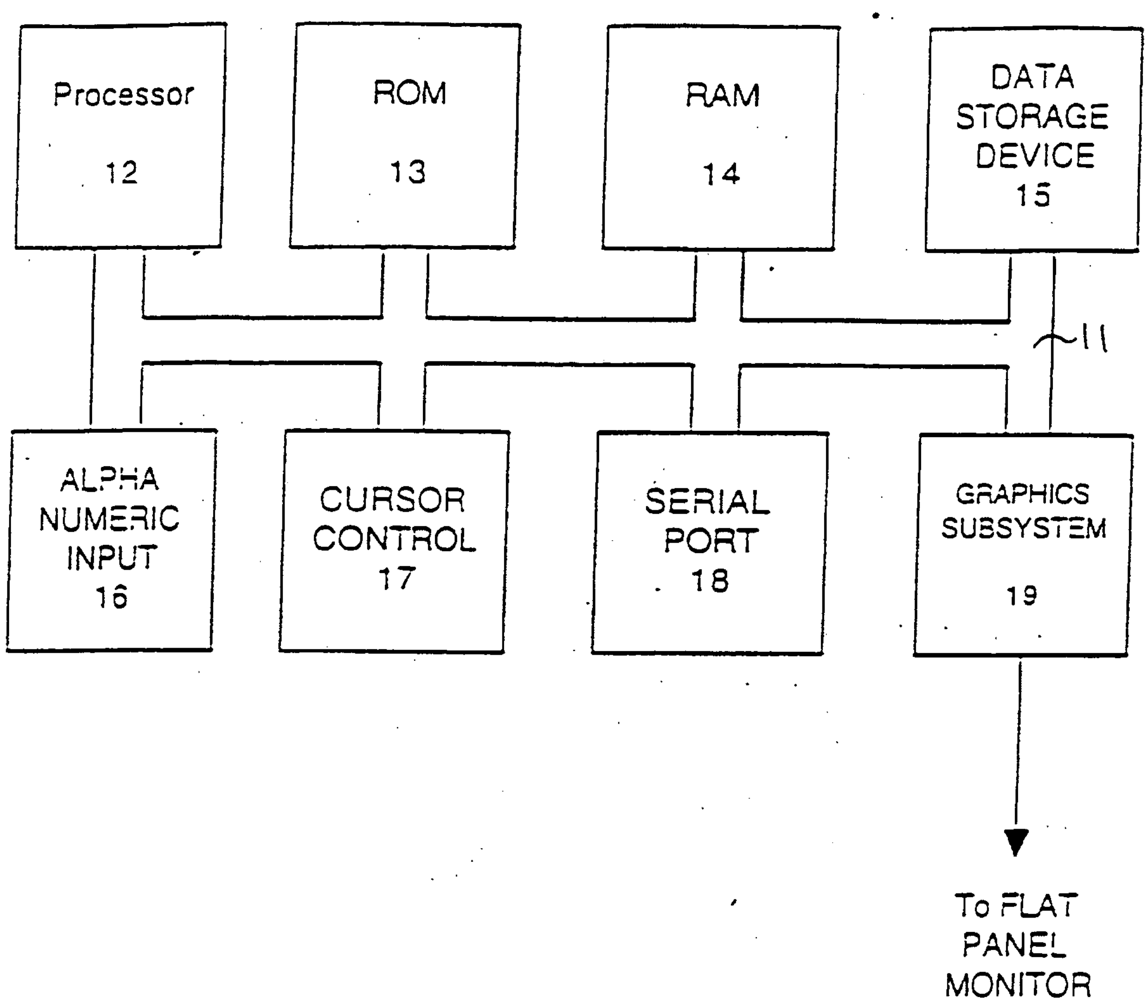

Processor
12
ROM
13
RAM
14
DATA
STORAGE
DEVICE
15
11
ALPHA
NUMERIC
INPUT
16
CURSOR
CONTROL
17
SERIAL
PORT
18
GRAPHICS
SUBSYSTEM
19
To FLAT
PANEL
MONITOR

FIG. 1

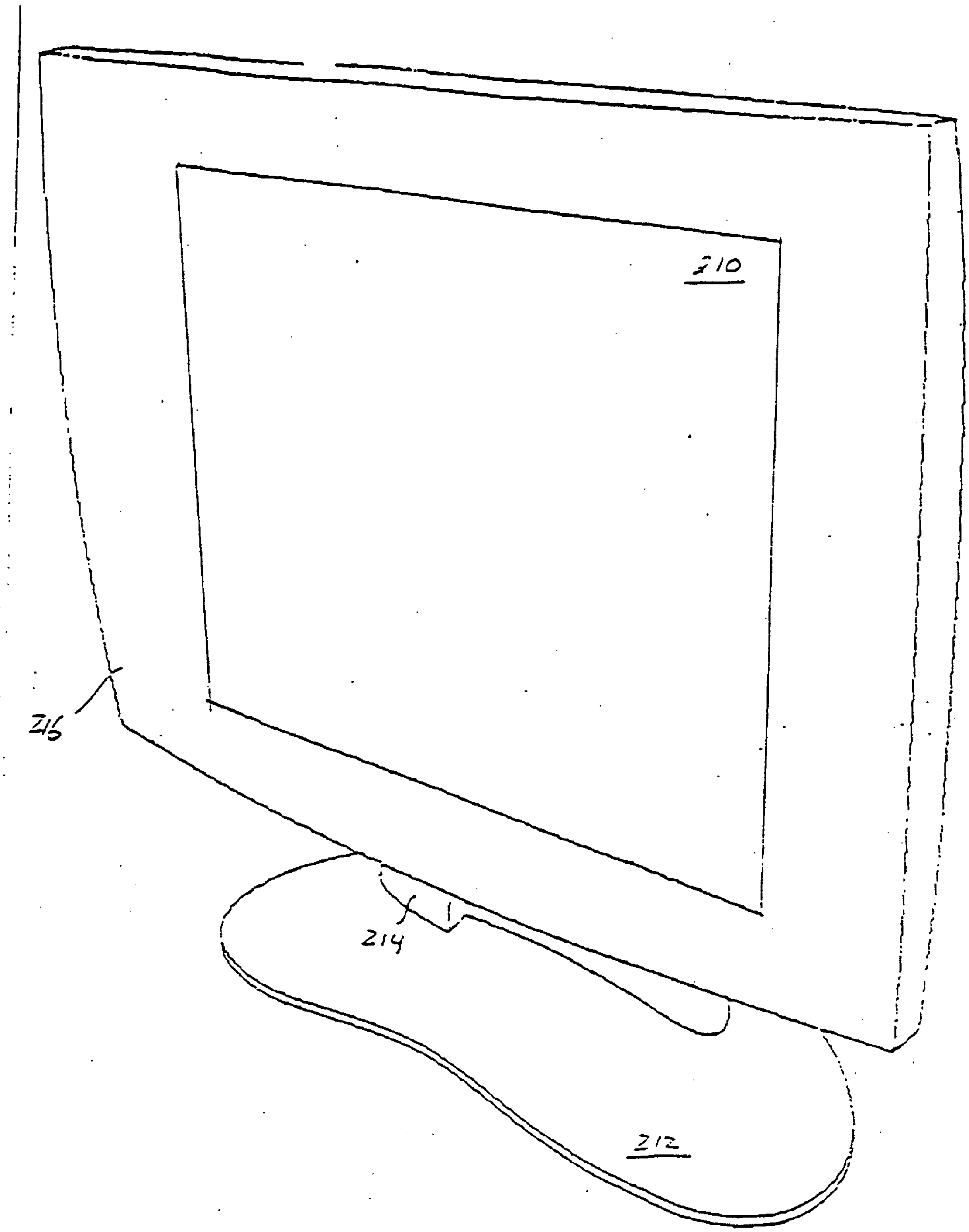


FIG. 2

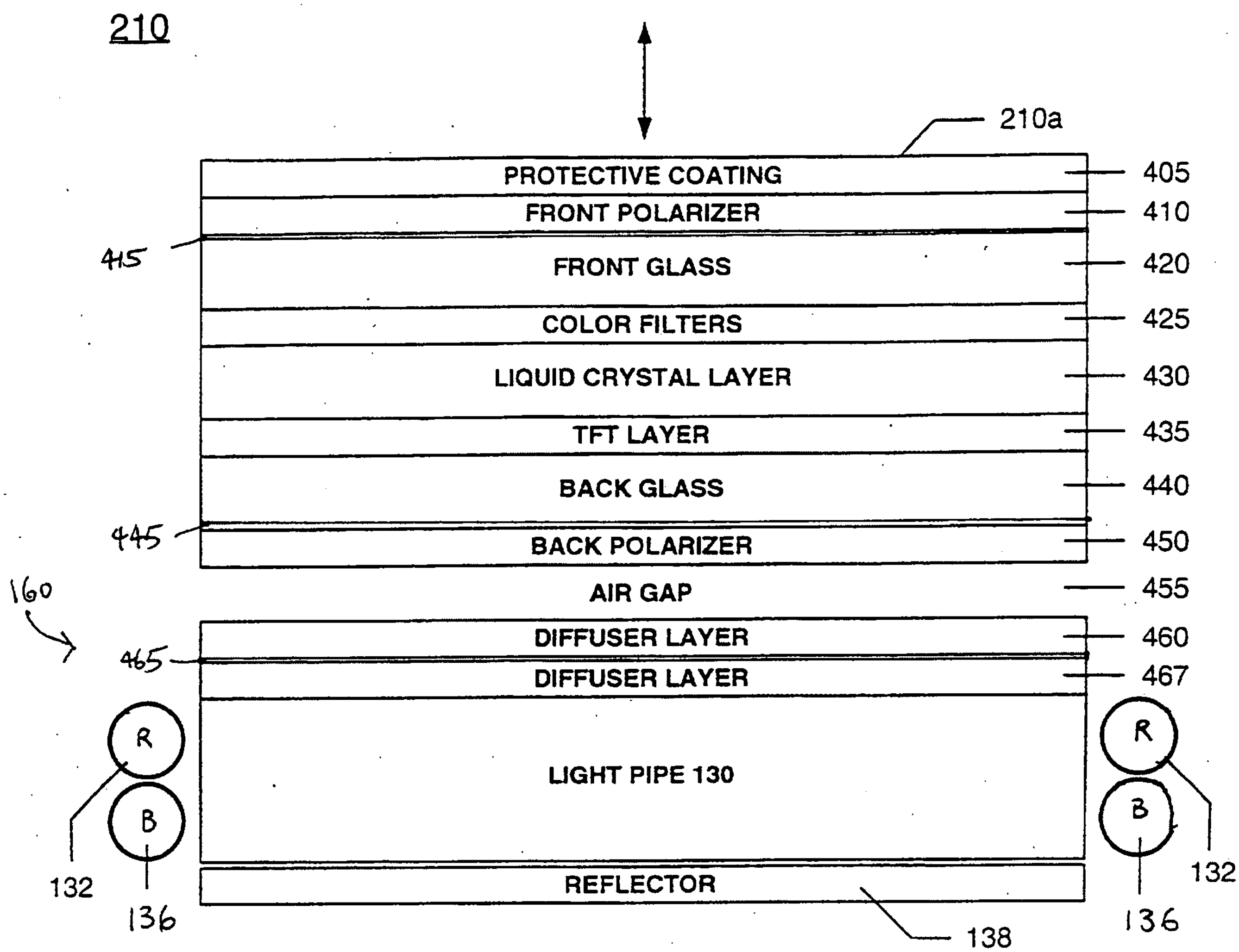

210
210a
PROTECTIVE COATING
405
FRONT POLARIZER
410
415
FRONT GLASS
420
COLOR FILTERS
425
LIQUID CRYSTAL LAYER
430
TFT LAYER
435
BACK GLASS
440
445
BACK POLARIZER
450
AIR GAP
455
160
DIFFUSER LAYER
460
465
DIFFUSER LAYER
467
R
B
LIGHT PIPE 130
132
136
REFLECTOR
138

FIG. 3

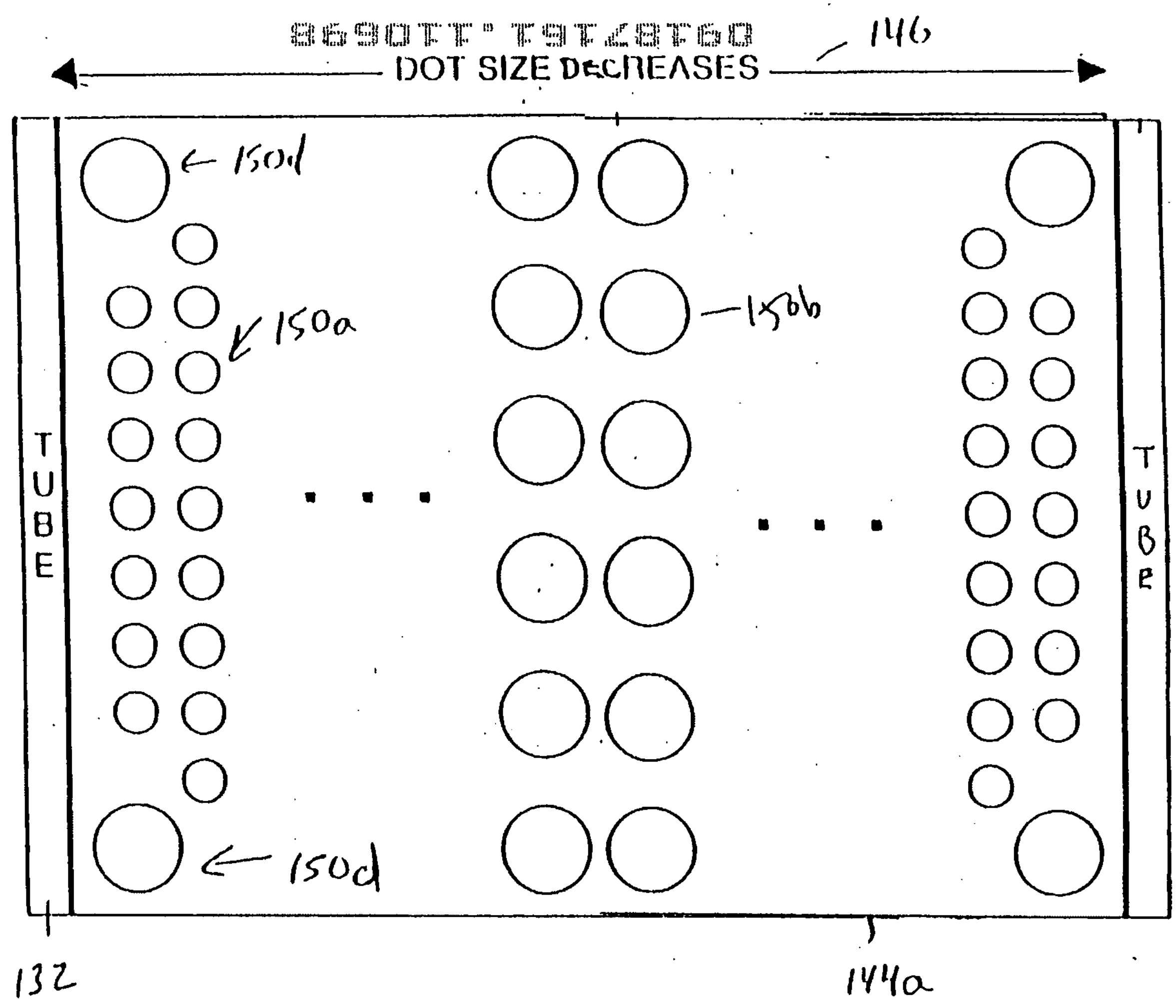
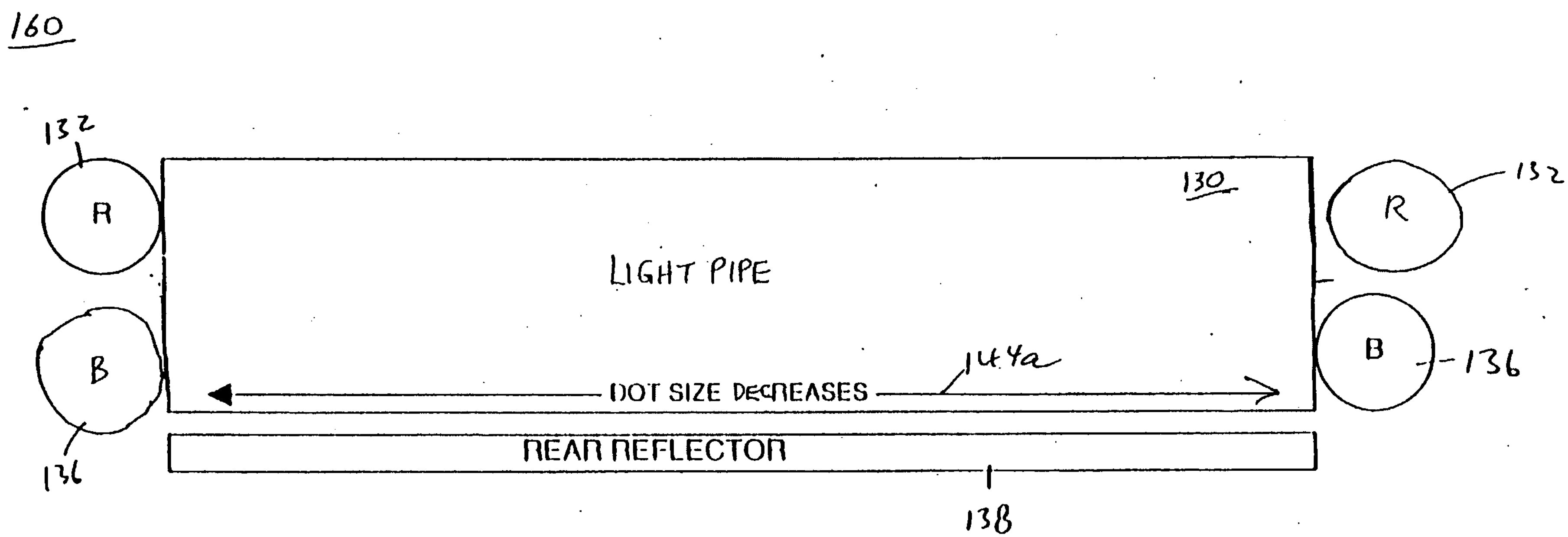

146
DOT SIZE DECREASES
150d
150a
150b
TUBE
TUBE
150d
132
144a

FIG. 4



160
132
R
B
136
130
LIGHT PIPE
144a
DOT SIZE DECREASES
REAR REFLECTOR
138
R
132
B
136

FIG. 5

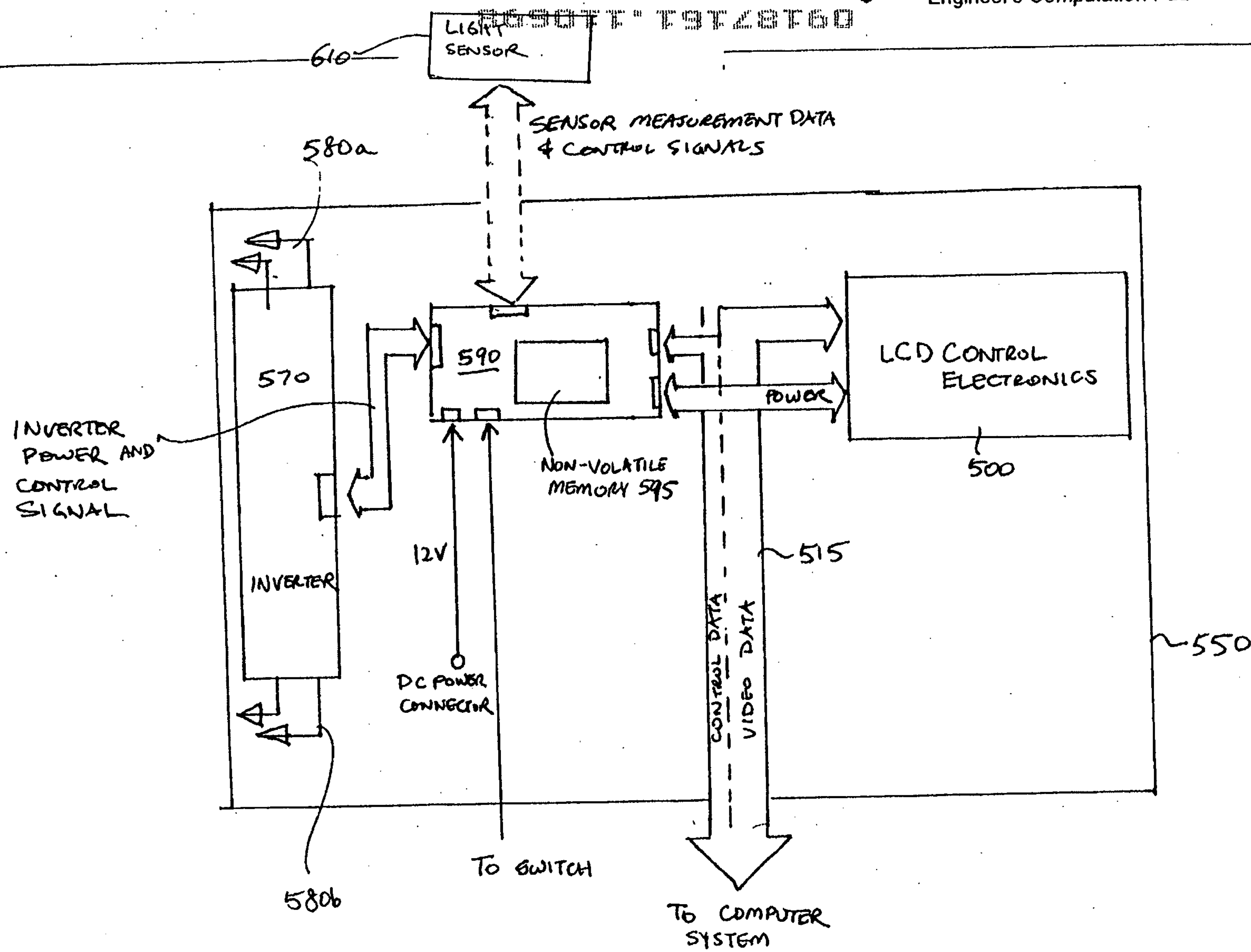

LIGHT SENSOR
610
SENSOR MEASUREMENT DATA & CONTROL SIGNALS
580a
570
INVERTER
INVERTER POWER AND CONTROL SIGNAL
590
NON-VOLATILE MEMORY 595
12V
DC POWER CONNECTOR
TO SWITCH
580b
LCD CONTROL ELECTRONICS
500
POWER
CONTROL DATA
VIDEO DATA
515
550
TO COMPUTER SYSTEM

FIG. 6

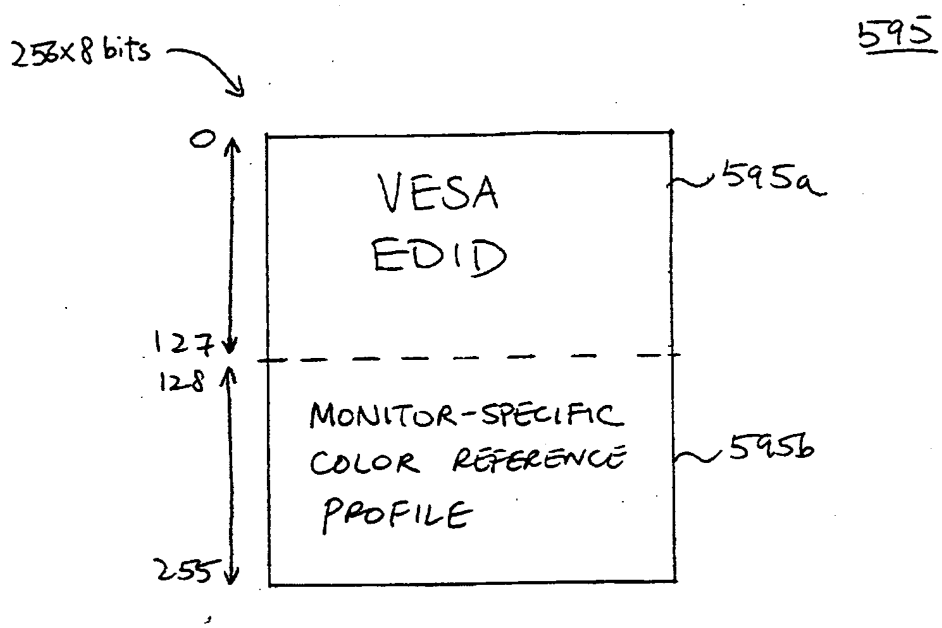

595
256x8 bits
0
VESA EDID
595a
127
128
MONITOR-SPECIFIC COLOR REFERENCE PROFILE
595b
255

FIG. 7

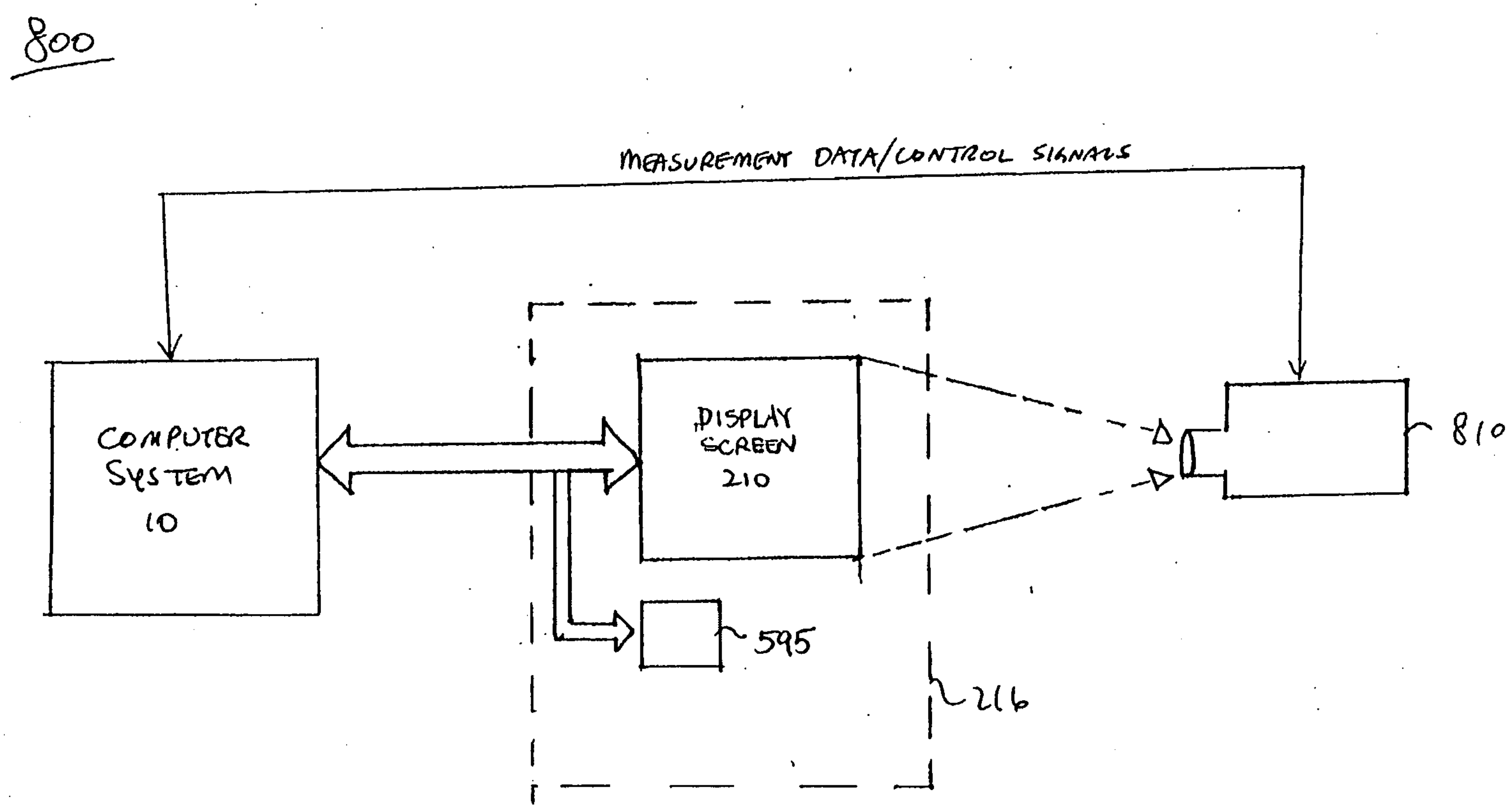

800
MEASUREMENT DATA/CONTROL SIGNALS
COMPUTER SYSTEM 10
DISPLAY SCREEN 210
595
216
810

FIG. 8

900

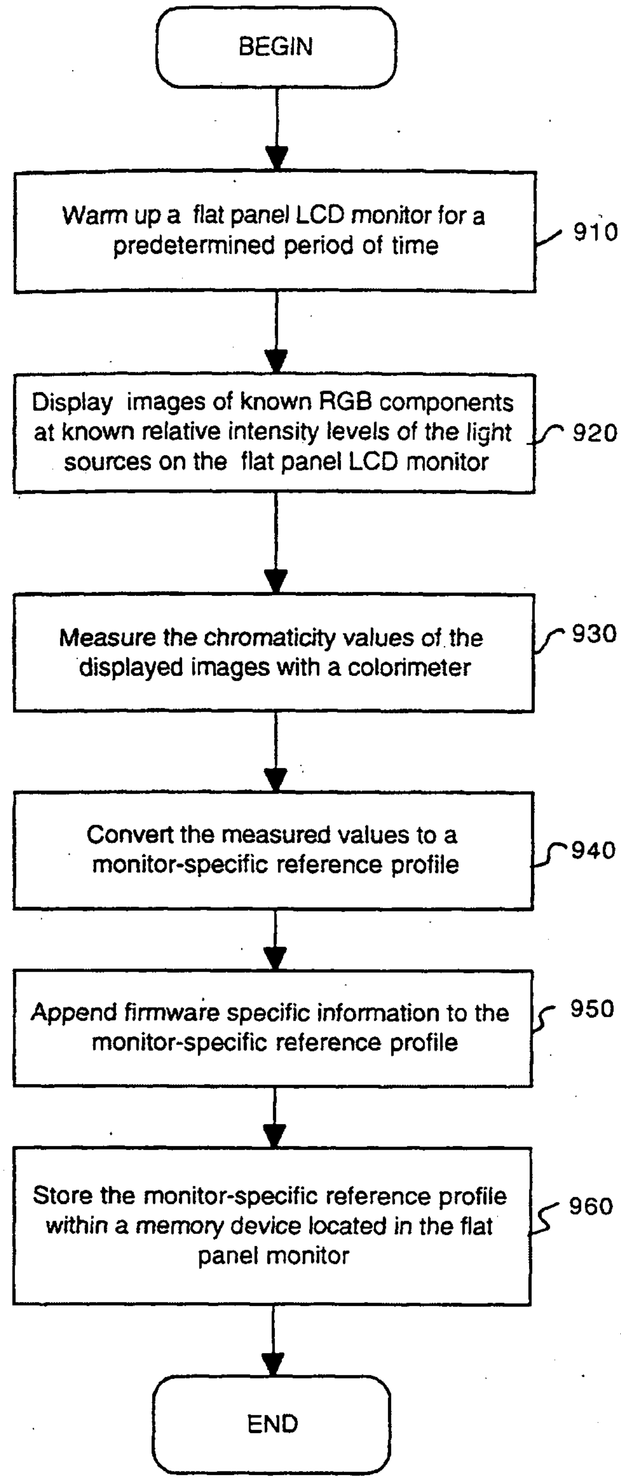

BEGIN
Warm up a flat panel LCD monitor for a predetermined period of time
910
Display images of known RGB components at known relative intensity levels of the light sources on the flat panel LCD monitor
920
Measure the chromaticity values of the displayed images with a colorimeter
930
Convert the measured values to a monitor-specific reference profile
940
Append firmware specific information to the monitor-specific reference profile
950
Store the monitor-specific reference profile within a memory device located in the flat panel monitor
960
END

FIG. 9